CLAIMS

1. A tank vent apparatus comprising

a valve housing formed to include an inlet port, an outlet port, and an interior region arranged to receive fuel vapor admitted into the valve housing through the inlet port and to communicate fuel vapor to the outlet port for discharge from the valve housing,

a partition located in the valve housing to divide the interior region into an upstream passageway arranged to receive liquid fuel and fuel vapor admitted into the interior region through the inlet port and a discharge chamber arranged to discharge fuel vapor from the interior region through the outlet port, the partition including an upright interior wall providing a valve seat located in the upstream passageway and formed to include at least one vent port configured to communicate fuel vapor from the upstream passageway into the discharge chamber, and

a vent port valve mounted for movement in the upstream passageway in an axially upward direction to a closed position engaging the valve seat and closing the at least one vent port and in an axially downward direction to an opened position disengaging at least a portion of the valve seat and opening the vent port to allow fuel vapor to flow in a radial direction through the vent port from the upstream passageway into the discharge chamber to be discharged from the interior region through the outlet port.

2. The apparatus of claim 1, wherein the vent port valve includes a float positioned to lie in the upstream passageway and a seal coupled to the float to move therewith in the upstream passageway relative to the valve seat to close the at least one vent port upon movement of the vent port valve to the closed position and to open the at least one vent port upon movement of the vent port valve to the opened position.

3. The apparatus of claim 2, wherein the upright interior wall is cylinder-shaped and formed to include the discharge chamber therein and the seal includes a base coupled to the float, a lip coupled to the upright interior wall, and a pliable annular membrane arranged to interconnect the base and the lip and configured to surround the upright interior wall and to roll back and forth relative to the valve seat and the at least one vent port formed therein as the float is raised and lowered in a

rising and falling pool of liquid fuel extant in the upstream passageway to close the at least one vent port upon movement of the vent port valve to the closed position and to open the at least one vent port upon movement of the vent port valve to the opened position.

4. The apparatus of claim 3, further comprising an interior sleeve located in the interior region of the valve housing to surround the upright interior wall and to divide the upstream passageway into an intake chamber arranged to receive liquid fuel and fuel vapor admitted into the interior region through the inlet port and a float chamber containing the float and the seal therein, and wherein the interior sleeve is formed to include at least one lower fuel port configured to provide means for conducting liquid fuel from the intake chamber into a lower region of the float chamber whenever liquid fuel is admitted into the interior region of the valve housing through the inlet port to provide the rising and falling pool of liquid fuel for raising and lowering the float in the float chamber, and the interior sleeve is also formed to include at least one upper vapor port configured to provide means for conducting pressurized fuel vapor from the intake chamber into an upper region of the float chamber whenever pressurized fuel vapor is admitted into the interior region of the valve housing through the inlet port so that such pressurized fuel vapor passes through the at least one vent port into the discharge chamber whenever the vent port valve is moved in the float chamber to assume the opened position.

5. The vent apparatus of claim 3, wherein the valve housing includes a top wall adapted to be mounted to a top wall of a fuel tank, a bottom wall positioned to lie below and in spaced-apart relation to the top wall, and an outer side wall arranged to extend from the top wall to the bottom wall to define the interior region therebetween, the outer side wall is formed to include the inlet port, and the bottom wall is formed to include the outlet port.

6. The apparatus of claim 3, wherein the valve housing includes a top wall adapted to be mounted to a top wall of a fuel tank, a bottom wall positioned to lie below and in spaced-apart relation to the top wall, and an outer side wall arranged to extend from the top wall to the bottom wall to define the interior region therebetween, the bottom wall is formed to include the outlet port, the upright interior wall is coupled to the bottom wall and arranged to extend upwardly toward the top wall, the float is ring-shaped and arranged to surround a lower portion of the upright

interior wall and lie adjacent to the bottom wall, and the pliable annular membrane is arranged to surround an upper portion of the upright interior wall that is located between the lower portion of the upright interior wall and the top wall of the valve housing and is formed to include the at least one vent port.

7. The apparatus of claim 2, wherein the upright interior wall is cylinder-shaped to define the discharge chamber therein and the float is ring-shaped and formed to include a central aperture receiving the upright interior wall therein to allow movement of the float relative to the upright interior wall.

8. The apparatus of claim 7, wherein the upright interior wall is formed to include the outlet port at a lower end thereof to conduct fuel vapor from the at least one vent port to the outlet port through the discharge chamber defined by the upright interior wall.

9. The apparatus of claim 7, wherein the valve housing includes a top wall adapted to be mounted to a top wall of a fuel tank, a bottom wall positioned to lie below and in spaced-apart relation to the top wall, and an outer side wall arranged to extend from the top wall to the bottom wall to define the interior region therebetween, the outer side wall is formed to include the inlet port, and the bottom wall is formed to include the outlet port and to place the outlet port in communication with the discharged chamber defined by the upright interior wall to cause fuel vapor passing from the upstream passageway into the discharge chamber through the at least one vent port when the vent port valve is moved to assume the opened position to be discharged from the interior region of the valve housing through the outlet port formed in the bottom wall.

10. The apparatus of claim 2, further comprising an interior sleeve located in the interior region of the valve housing to surround the upright interior wall and to divide the upstream passageway into an intake chamber arranged to receive liquid fuel and fuel vapor admitted into the interior region through the inlet port and a float chamber containing the float and the seal therein, the interior sleeve is formed to include at least one lower fuel port configured to provide means for conducting liquid fuel from the intake chamber into a lower region of the float chamber whenever liquid fuel is admitted into the interior region of the valve housing through the inlet port to provide the rising and falling pool of liquid fuel for raising and lowering the float in the float chamber, and the interior sleeve is also formed to include at least one upper

vapor port configured to provide means for conducting pressurized fuel vapor from the intake chamber into an upper region of the float chamber whenever pressurized fuel vapor is admitted into the interior region of the valve housing through the inlet port so that such pressurized fuel vapor passes through the at least one vent port into the discharge chamber whenever the vent port valve is moved in the float chamber to assume the opened position.

11. The apparatus of claim 10, wherein the valve housing includes a top wall arranged to intersect the central vertical axis of the valve housing and adapted to be mounted to a top wall of a fuel tank, a bottom wall arranged to intersect the central vertical axis of the valve housing and positioned to lie below and in spaced-apart relation to the top wall, and an outer side wall arranged to extend from the top wall to the bottom wall to define the interior region therebetween, the outer side wall is formed to include the inlet port, and the bottom wall is formed to include the outlet port.

12. The apparatus of claim 1, wherein the valve housing has a central vertical axis, the upright interior wall is cylinder-shaped and has a central vertical axis that is coextensive with the central vertical axis of the valve housing, and the upright interior wall is formed to include the discharge chamber therein.

13. The apparatus of claim 12, wherein the valve housing includes a top wall arranged to intersect the central vertical axis of the valve housing and adapted to be mounted to a top wall of a fuel tank, a bottom wall positioned to lie below and in spaced-apart relation to the top wall, an outer side wall arranged to extend from the top wall to the bottom wall to define the interior region therebetween, and the bottom wall is formed to include the outlet port at a lower end of the upright interior wall to cause fuel vapor in the discharge chamber to flow out of the interior region of the valve housing through the outlet port.

14. The apparatus of claim 13, wherein the inlet port is formed in the outer side wall of the valve housing and further comprising an interior sleeve located in the interior region of the valve housing to surround the upright interior wall and to divide the upstream passageway into an intake chamber arranged to receive liquid fuel and fuel vapor admitted into the interior region through the inlet port and a float chamber lying between the intake and discharge chambers and containing the vent port valve therein, the interior sleeve is formed to include a lower fuel port near

the bottom wall to conduct liquid fuel from the intake chamber to the float chamber and an upper vapor port near the top wall to conduct fuel vapor from the intake chamber to the float chamber for delivery to the discharge chamber when the vent port valve is moved to assume the opened position.

15. The apparatus of claim 14, wherein each of the outer side wall and the interior sleeve is cylinder-shaped and has a central vertical axis that is coextensive with the central vertical axis of the valve housing.

16. The apparatus of claim 1, further comprising a vent unit configured to provide vent means for admitting fuel vapor into the upstream passageway when liquid fuel admitted into the upstream passageway through the inlet port rises to a level in the upstream passageway to occlude the inlet port and block passage of fuel vapor therethrough so that fuel vapor continues to be admitted into the upstream passageway for delivery to the discharge chamber when the vent port valve is moved to assume the opened position.

17. The apparatus of claim 16, wherein the vent unit is positioned to lie in the upstream passageway and an inlet channel is formed in the valve housing to admit fuel vapor into the vent means provided in the vent unit.

18. The apparatus of claim 16, wherein the vent means includes a movable head valve normally at rest on a valve seat formed to include a vent passageway to close the vent passageway, the head valve is located in a valve chamber defined by a chamber wall rising up from the valve seat, the chamber wall is formed to include an opening to pass pressurized fuel vapor in the valve chamber into the upstream passageway for delivery to the discharge chamber when the vent port valve is moved to assume the opened position.

19. The apparatus of claim 18, wherein the vent means further includes a bleed passageway formed in the vent unit to meter a flow of pressurized fuel vapor from a location outside the valve housing into the valve chamber regardless of whether the head valve is positioned to open or close the vent passageway formed in the valve seat.

20. The apparatus of claim 1, further comprising a remote fuel and vapor inlet unit coupled to the inlet port of the valve housing and a transfer conduit coupled to the remote fuel and vapor inlet unit and adapted to transfer liquid fuel and fuel vapor admitted into the remote fuel and vapor inlet unit from a fuel tank

containing the remote fuel and vapor inlet unit into the upstream passageway formed in the valve housing, the remote fuel and vapor inlet unit includes an inlet chamber, an inlet port communicating with the inlet chamber to admit liquid fuel and fuel vapor therein, a drain port communicating with the inlet chamber, an outlet coupled to the transfer conduit, and drain-control means for controlling opening and closing of the drain port.

21. The apparatus of claim 20, wherein the remote fuel and vapor inlet includes a floor located to provide a lower boundary of the inlet chamber and formed to include the drain port to facilitate drainage of liquid fuel from the inlet chamber and the drain-control means includes a cage that depends from the floor of the remote fuel and vapor inlet and extends around and below the drain port and a buoyant drain closure retained inside the cage and configured to float in liquid fuel admitted into the cage to move in the cage between an opened position away from the drain port to allow any residual liquid fuel in the inlet chamber to drain out of the inlet chamber through the drain port and the cage and a closed position engaging a valve seat surrounding the drain port to close the drain port.

22. A tank vent apparatus comprising

a valve housing including a top wall adapted to be mounted to a top wall of a fuel tank, a bottom wall positioned to lie in spaced-apart relation to the top wall, and an outer side wall arranged to cooperate with the top and bottom walls to define an interior region, the outer side wall being formed to include an inlet port to communicate liquid fuel and fuel vapor into the interior region, the bottom wall being formed to include an outlet port to discharge fuel vapor from the interior region to a destination outside of the valve housing, and

flow-control means located in the interior region of the valve housing for blocking flow of liquid fuel admitted into the interior region through the inlet port from the interior region through the outlet port and allowing flow of pressurized fuel vapor admitted into the interior region to flow from the interior region through the outlet port until liquid fuel extant in the interior region rises above the bottom wall to a level in excess of a predetermined level.

23. The apparatus of claim 22, wherein the flow-control means includes a cylinder-shaped interior wall coupled to the bottom wall at the outlet port and formed to define a discharge chamber to conduct fuel vapor to the outlet port

formed in the bottom wall and at least one vent port configured to admit pressurized fuel vapor into the discharge chamber, the flow-control means further includes a cylinder-shaped interior sleeve positioned to lie in the interior region between the outer side wall and the cylinder-shaped interior wall and surround the cylinder-shaped interior wall to define an intake chamber arranged to receive liquid fuel and fuel vapor admitted into the interior region through the inlet port formed in the outer side wall and a float chamber located between the intake and discharge chambers and in communication with the at least one vent port formed in the cylinder-shaped interior wall, the cylinder-shaped interior sleeve is formed to include a lower fuel port near the bottom wall to conduct liquid fuel from the intake chamber to the float chamber and an upper vapor port near the top wall to conduct fuel vapor from the intake chamber to the float chamber, and the flow-control means further includes a vent port valve mounted for movement in the float chamber to open and close the at least one vent port to regulate flow of pressurized fuel vapor from the float chamber into the discharge chamber through the at least one vent port.

24. The apparatus of claim 23, wherein the vent port valve includes a float and a seal positioned to lie between the float and the top wall of the valve housing and coupled to the float to move therewith to close the at least one vent port upon movement of the vent port valve in the float chamber toward the top wall of the valve housing to a closed position and to open the at least one vent port upon movement of the vent port valve in the float chamber toward the bottom wall of the valve housing.

25. The apparatus of claim 24, wherein the seal includes a base coupled to the float, a lip coupled to the interior wall at a location between the at least one vent port and the bottom wall, and a pliable annular membrane arranged to interconnect the base and the lip and configured to surround a portion of the cylinder-shaped interior wall and to roll back and forth relative to the portion of the cylinder-shaped interior wall and the at least one vent port formed therein as the float is raised and lowered in a rising and falling pool of liquid fuel extant in the float chamber to close the at least one vent port upon movement of the vent port valve in the float chamber to the closed position.

26. The apparatus of claim 23, wherein the valve housing includes a central vertical axis extending through the top and bottom walls and each of the

cylinder-shaped interior wall, interior sleeve, and outer side wall has a central vertical axis that is coextensive with the central vertical axis of the valve housing.

27. The apparatus of claim 22, wherein the flow-control means includes a cylinder-shaped interior wall coupled to the bottom wall at the outlet port and formed to define a discharge chamber to conduct fuel vapor to the outlet port and at least one vent port configured to admit pressurized fuel vapor into the discharge chamber, an annular float formed to include a central aperture receiving the cylinder-shaped interior wall therein and positioned to lie in the interior region of the valve housing for movement along the cylinder-shaped interior wall and between the top and bottom walls of the valve housing, and a seal including a base coupled to the float, a lip coupled to the cylinder-shaped interior wall at a location between the at least one vent port and the bottom wall, and a pliable annular membrane arranged to interconnect the base and the lip and configured to surround a portion of the cylinder-shaped interior wall and to roll back and forth relative to the portion of the cylinder-shaped interior wall and the at least one vent port formed therein as the float is raised and lowered in a rising and falling pool of liquid fuel extant in the interior region outside of the discharge chamber to close the at least one vent port.

28. The apparatus of claim 22, further comprising a remote fuel and vapor inlet unit and a transfer conduit coupled to the remote fuel and vapor inlet unit and adapted to transfer liquid fuel and fuel vapor admitted into the remote fuel and vapor inlet unit from a fuel tank containing the remote fuel and vapor inlet unit into the interior region formed in the valve housing, the remote fuel and vapor inlet unit includes an inlet chamber, an inlet port communicating with the inlet chamber to admit liquid fuel and fuel vapor therein, a drain port communicating with the inlet chamber, an outlet coupled to the transfer conduit, and drain-control mean for controlling opening and closing of the drain port.

29. The apparatus of claim 28, wherein the remote fuel and vapor inlet includes a floor located to provide a lower boundary of the inlet chamber and formed to include the drain port to facilitate drainage of liquid fuel from the inlet chamber and the drain-control means includes a cage that depends from the floor of the remote fuel and vapor inlet and extends around and below the drain port and a buoyant drain closure retained inside the cage and configured to float in liquid fuel admitted into the cage to move in the cage between an opened position away from the

drain port to allow any residual liquid fuel in the inlet chamber to drain out of the inlet chamber through the drain port and the cage and a closed position engaging a valve seat surrounding the drain port to close the drain port.

30. The apparatus of claim 22, wherein the valve housing is formed to include an inlet channel open to receive fuel vapor extant outside of the valve housing and further comprising a vent unit located in the interior region of the valve housing, the vent unit including a valve seat formed to include a vent passageway located to receive pressurized fuel vapor passing into the valve housing through the inlet channel and a chamber wall rising up from the valve seat to define a valve chamber and providing an opening to pass pressurized fuel vapor in the valve chamber into the interior region of the valve housing for delivery to the discharge chamber, the vent unit further including a movable head valve normally at rest on the valve seat to close the vent passageway and arranged to move in the valve chamber away from the valve seat to open the vent passage in response to presence of pressurized fuel vapor in the inlet channel in excess of a predetermined pressure.

31. The apparatus of claim 30, wherein the vent unit is formed to include a bleed passageway sized to meter a flow of pressurized fuel vapor from a location outside the valve housing into the valve chamber regardless of whether the head valve is positioned to open or close the vent passageway formed in the valve seat.

32. The apparatus of claim 31, wherein the valve seat is formed to include the bleed passageway and the bleed passageway has an inlet opening communicating with the inlet channel and an outlet opening communicating with the valve chamber.

33. A tank vent apparatus comprising

a valve housing including a top wall adapted to be mounted to a top wall of a fuel tank, a bottom wall positioned to lie in spaced-apart relation to the top wall, and an outer side wall arranged to cooperate with the top and bottom walls to define an interior region, the outer side wall being formed to include an inlet port to communicate liquid fuel and fuel vapor into the interior region, the bottom wall being formed to include an outlet port to discharge fuel vapor from the interior region to a destination outside of the valve housing,

a remote fuel and vapor inlet unit positioned to lie below the bottom wall of the valve housing and formed to include an inlet chamber, an inlet port communicating with the inlet chamber to admit liquid fuel and fuel vapor therein, a drain port communicating with the inlet chamber, an outlet, and drain-control means for controlling opening and closing of the drain port, and

a transfer conduit coupled to the outlet of the remote fuel and vapor inlet unit and to the inlet port formed in the outer side wall of the valve housing to transfer liquid fuel and fuel vapor admitted into the remote fuel and vapor inlet unit through the inlet port formed therein into the interior region of the valve housing through the inlet port formed in the outer side wall of the valve housing.

34. The apparatus of claim 33, wherein the remote fuel and vapor inlet includes a floor located to provide a lower boundary of the inlet chamber and formed to include the drain port to facilitate drainage of liquid fuel from the inlet chamber and the drain-control means includes a cage that depends from the floor of the remote fuel and vapor inlet and extends around and below the drain port and a buoyant drain closure retained inside the cage and configured to float in liquid fuel admitted into the cage to move in the cage between an opened position away from the drain port to allow any residual liquid fuel in the inlet chamber to drain out of the inlet chamber through the drain port and the cage and a closed position engaging a valve seat surrounding the drain port to close the drain port.